# Improved Sub-Grid Physical Parameterization Schemes for NOGAPS

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## LONG-TERM GOAL

The ultimate goal of this project is to improve the global numerical weather predictions for DOD. This objective is obtained by developing state-of-the-art physical parameterizations for the Navy Operational Global Atmospheric Prediction System (NOGAPS) that clearly demonstrate a superior statistical skill over existing techniques when tested in a data assimilation cycle similar to that used in operations.

## OBJECTIVES

The objective of this project is to improve the sub-grid physical parameterizations used in the forecast model of the Navy's global numerical weather forecast system to reduce its systematic errors and improve its tropical cyclone predictions. The productss from this model are used to provide weather information for military planning and exercises; to provide boundary conditions for mesoscale models; and to provide surface fluxes to ocean, wave, and ice prediction models. Accurate depictions of the atmosphere with a range of scales from global to mesoscale, for weather phenomena such as tropical cyclones, fronts, and intense precipitation, depend crucially on proper simulations of the sub-grid scale physical processes. The payoffs for improving the global forecast system through the improvement of physical parameterizations will provide improved forecast guidance and products for many Fleet activities such as ship routing, flight planning, mission planning, and weather hazard avoidance.

## APPROACH

The sub-grid scale processes in NOGAPS include convective and large-scale precipitation, long-wave and solar radiation and their interactions with cloud, planetary boundary layer turbulent mixing, and the determination of surface fluxes. The parameterization schemes to represent these sub-grid scale processes need to be constantly evaluated and improved to comply with the improvement of model resolution, adoption of new types of data and improved understanding of the sub-grid scale processes. The existing parameterizations are either improved based on new observation data, or replaced by new and more advanced schemes. Extensive testing will be carried out on every modification and improvement. An optimized version of the parameterization scheme will be implemented in the model and transitioned for operational checkout.

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## WORK COMPLETED

In FY 2000 the project focused on identifying systematic errors and evaluating the predictions of weather systems. Analyses of tropical cyclone predictions using the existing Arakawa-Schubert cumulus parameterization scheme showed some unrealistic vertical structure in the simulated storms. A new convective parameterization scheme, the Emanuel scheme, was implemented and tested in NOGAPS. The Emanuel scheme was designed to include sub-cloud drafts and has been demonstrated to be superior to the relaxed Arakawa-Schubert (RAS) scheme in NOGAPS. After extensive testing, the Emanuel scheme was chosen to replace the existing RAS convective scheme. An effort is continuing to further improve the under-prediction bias of the Emanuel scheme for heavy rainfall events. Research and development work is ongoing for improving the surface fluxes and stresses, gravity wave drag, and radiation schemes. Conference and journal articles have been written and submitted for the new cumulus parameterization scheme.

## RESULTS

The research in this project resulted in the transition of a new cumulus parameterization scheme for NOGAPS. The incorporation of this new scheme has led to a significant decrease of the forecast systematic errors and a significant reduction of the tropical cyclone track forecast errors.

## IMPACT/APPLICATION

Safe and efficient operation of ships and aircraft at sea and ashore highly depends on accurate predictions of hazardous weather and sea conditions. Mission planning, rehearsal, and execution require knowledge of current and future atmospheric and ocean conditions. A staggering range of spatial and temporal scales must be addressed, from cloud droplets to global weather patterns and from instant support for low-flier detection to 10-day predictions for mission planning. NOGAPS is central to all requirements for environmental support. Not only does NOGAPS provide the weather information needed for global-wide support of DOD assets, it also provides the boundary conditions for tactical scale atmospheric prediction systems and provides the forcing for ocean, ice, and wave predictions. Thus improvements in the global model have far-reaching DOD implications.

In addition to benefiting all of the DOD and broader defense-related activities, technology developed at NRL is also being used by other civilian agencies. For example, NOGAPS has earned strong respect as a skillful hurricane forecast model, and the NOGAPS forecasts are frequently referred to in the official guidance issued by NOAA's Tropical Prediction Center. Furthermore, graphical NOGAPS products made available by FNMOC over the Internet are used by National Weather Service and public media forecasters as additional guidance when preparing their local forecasts. The significant improvements in the model forecasts by the introduction of the Emanuel scheme has aroused a wide interest in this scheme at other operational numerical prediction centers.

## TRANSITIONS

The results of this work have been transitioned to 6.4 (Large-scale Atmospheric Models, PE 0603207N, task X-2342, SPAWAR PMW-185) and have become part of the latest operational version of NOGAPS.

## RELATED PROJECTS

This atmospheric model development effort is part of our vertically integrated program for basic (6.1) and advanced (6.2) research as well as transition to operations (6.4). Related advanced development (6.2) projects within PE 0602435N are BE-35-2-20, 035-32, 035-33, BE-35-2-19, 035-71, 035-23, and BE-35-2-32, which focus on the development of data assimilation systems, prediction of aerosols, development of coupled air-ocean-wave prediction systems, and the utilization of massively parallel computer architecture for solution of non-linear prediction systems. The related 6.4 project under PE 0603207N is the Large-scale Atmospheric Models project, which focuses on the transition of the 6.2 development to operations at FNMOC.

## PUBLICATIONS

Peng, M. S., and T. F. Hogan, 2000: Performance of NOGAPS on the Predictions of Tropical Cyclones using different Convective Parameterization Schemes. Twenty-Fourth Conference on Hurricanes and Tropical Meteorology, May 29-June 3. Ft. Lauderdale, FL.

Peng, M. S., and T. F. Hogan, 1999: Performance of NOGAPS on the Predictions of Tropical Cyclones using different Convective Parameterization Schemes. Proceeding of the Fourth Conference on Eastern Asia and Western Pacific Meteorology and Climate. Oct 25-28, 1999. Hang-Zhou, China, World Scientific Publication, Singapore. (Accepted for publication).